Making Museum Exhibits Accessible for All: Approaches to Multi-Modal Exhibit Personalization

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Executive Summary

Creating Museum Media for Everyone is an NSF-funded collaborative project of the Museum of Science, the WGBH National Center for Accessible Media, Ideum, and Audience Viewpoints, to further the science museum field's understanding of ways to research, develop, and evaluate digital interactives that are inclusive of all people.[1] As a part of this effort to enable museums to integrate more accessible media into their exhibits to make them more welcoming and educational for visitors with disabilities as well as general audiences, this paper provides an overview of approaches to media accessibility museums currently use and new approaches supported by the latest research on accessibility and personalization. Personalization creates another alternative, beyond the application of universal design principles, to enable more inclusivity while enhancing the quality of the exhibition design. The perspectives, technologies, and resources presented will be a useful guide as museum design teams begin their next exhibit design.

Current Exhibit Design

Museum exhibit design is a collaborative process that typically starts with target educational goals for target audiences. The target audience might represent a relatively narrow age range, such as in a children's exhibit, or it might target a broad age and knowledge range, such as at a standard science museum. In many cases, the design process attempts to identify and use elements that are appropriate to the broadest spectrum of visitors within the target group. For text in the exhibit, for example, designers choose appropriate language levels and wording, and display it with the largest font size that can fit comfortably within the available real estate of the exhibit, to create an exhibit appropriate and acceptable to the target audience.

As notions of accessibility for people with sensory and cognitive disabilities have crept into the exhibit design process, efforts have increased to include design elements that serve additional visitors, thereby broadening the target group. Where, for example, past exhibits might have included only text with visuals or dioramas, some exhibit designs now include audio elements that read aloud the text. A few museums have general design requirements that always include such audio elements, and this has certainly served to make many exhibits much more generally accessible. This white paper offers techniques and suggestions to help all museums become more accessible.

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[1] The CMME project is supported by the National Science Foundation under Grant #1114549. http://openexhibits.org/research/cmme/

Approaches to Accessible Exhibit Design

For the purpose of this document, accessibility is defined as the process of making spaces or materials usable by people with disabilities. The range of approaches to accessibility includes regulations, curb cuts, universal design, and personalization. Museums have been working hard in recent years to expand the range of visitors who can learn from their exhibits, using combinations of these approaches.

The common perception of accessibility problems is that they are solved by making targeted changes that only benefit the group of people with disabilities for which they are required. Technology developers may think that implementing accessible design requires specific knowledge that they don't have, or is too expensive, requiring a lot of extra work. However, many accessibility improvements can be implemented in the design stage by considering a wide range of visitors with a variety of abilities. Accessibility features are useful to a wider group than just the visitors with disabilities who inspire them.

Museums, as with other areas of life, are increasingly digital. Digital exhibits that follow traditional design processes may be more interactive, but may not be accessible to all visitors. For example, if the interface remains primarily visual, visitors who are blind or have low vision or who have difficulty reading will continue to be denied access, and if the interface relies on audio feedback, it won't be accessible to people who are deaf or hard of hearing. Exhibits also may not be useable by people with cognitive disabilities. A variety of approaches to accessibility can guide exhibit designers toward greater inclusivity.

Regulation

Substantial regulation is in place in the U.S. and elsewhere that mandates physical accessibility of public spaces. The Americans with Disabilities Act (ADA) and accompanying detailed regulations make clear the responsibilities of museums to visitors with a broad range of disabilities, beyond those who are wheelchair users. The physical environment is not easy to adapt for individual visitors at the time of their visit; physical requirements (such as those that address wheelchair users or visitors who are blind or have low vision who use canes) must be met during construction or renovation. More information on these requirements is available in the Smithsonian Guidelines for Accessible Design, the Association of Science-Technology Centers' Resource Center, and in "Everyone's Welcome: The Americans with Disabilities Act and Museums" (Salmen 1998). The ADA also requires that all of a museum's goods and services be accessible, including exhibits, and has provided inspiration for the changes already seen in many museums, even without a set of detailed regulations.

The U.S. introduced groundbreaking regulations for accessible electronic and information technology with the standards for Section 508 of the Rehabilitation Act. The Section 508 standards (which are currently in the process of being refreshed) give detailed, functional requirements for making software and hardware accessible. However, the requirements apply only to the federal government and its development or procurement of technology. Many other organizations have taken the Section 508 standards as guidelines for creating accessible technology, but only the U.S. federal government is obligated to follow these

regulations. Even these more detailed regulations, unfortunately, may not match well with exhibit design practices.

In the UK, the Equality Act of 2010 requires equal access to all public facilities and services, which includes museums. It includes a requirement to take reasonable steps to ensure accessibility of information that is provided to the public. It does not have detailed requirements about technology, in the Act or in the Statutory Code of Practice provided by the Equality and Human Rights Commission.

Regulations set the broad outlines of what is required to offer accessible museum experiences to visitors with disabilities. Details drawn from other approaches will fill in those outlines.

Curb Cuts

Curb cuts, those little ramps at the corners of sidewalks, were originally created to allow wheelchair users to get on and off of sidewalks. However, they are commonly used by families with strollers, shoppers with shopping carts, and roller skaters and skateboarders. They have even inspired the creation of a whole new product category: the wheelie suitcase. Suitcases with wheels are now ubiquitous because travelers know that most places they go, they can pull their luggage behind them and rarely encounter a curb that requires lifting their suitcase.

The most popular "digital curb cut" is captioning for television. Since a closed caption decoder chip became a mandatory part of every U.S. television set after passage of the Television Decoder Circuitry Act of 1990, and networks began mandatory captioning of most programming, display of captions in public places has become common. We now expect to see captions on silent televisions in bars, gyms, and airports. Captions have proved to be useful for English language learners, for children learning to read, for people in quiet places who wish to turn off the sound on their TVs, and for people in noisy places who can't hear the soundtrack very well.

"Curb cuts," then, is a shorthand for those adaptations which are thought to be accessibility features but which turn out to be useful for far larger audiences than originally planned. When carefully planned, many museum efforts for accessibility can serve more than just visitors with disabilities, so it is useful to ask, "Could this be a curb cut?" during the design process.

Universal Design

Universal design (UD) is a concept originated by Ron Mace, the founder of the Center for Universal Design in North Carolina. Mace was an architect with a disability. He wrote that universal design is "an approach to design that incorporates products as well as building features which, to the greatest extent possible, can be used by everyone" (Mace, 1988). The original principles of UD were focused on the accessibility of the built environment.

Universal design for learning (UDL) is the result of applying UD principles to educational experiences. It is an approach to learning that uses "multiple means of representation (to

allow various ways of acquiring information and knowledge), multiple means of expression (to allow alternatives for demonstrating knowledge), and multiple means of engagement (to challenge appropriately, to motivate, and to allow learners to express and participate in their interests)" (CAST, 2010).

UDL is a good fit for museums because it suggests a focus on broadening the ways we present exhibit components and the kinds of interaction they elicit from visitors. For example, ideas can be presented with audio, with text, and with illustrations that reinforce the same messages, to offer several ways to perceive the material. Interactive components can ask visitors to manipulate on-screen objects, play with physical models, think about questions that take ideas a step further, and so on, to support multiple means of expression.

Current exhibit design practices already engage in UDL in many cases, with the different means of representation, expression, and engagement deployed in different exhibit components. Components might be aimed at different age groups, with different cognitive needs and language capabilities. They might have different interactive capabilities and call on different kinds of engagement, from reflective learning activities to those that require more action. We recognize the value of meeting different visitor needs in different components, but challenge designers to also work to include a broader range of visitors in each component.

Universal design techniques, such as the use of multiple modalities to communicate information, have been shown to increase the quality of exhibits (Davidson, Heald, & Hein, 1991; Reich 2006). However, this model relies on redundancies in communication (where information is conveyed through text, audio, and images simultaneously). Making these redundancies available to all visitors poses two problems:
- some visitors become overwhelmed by the amount of information being communicated because they feel that they need to absorb all of the information that is made available to them, not realizing it is intentionally duplicated, and
- some visitors with disabilities can feel unintentionally left out of the experience because they perceive, based on their history of exclusion, that the modality they cannot access provides additional information that they need. When designers weave the different modalities together, rather than making them explicit alternatives to each other, users may have trouble trusting that they are getting the whole exhibit.

Personalization
Increasingly complex exhibits, merging science, history, and art, are attracting an increasingly sophisticated audience accustomed to using digital interfaces in their everyday lives. Personalization for accessibility creates another alternative, beyond the application of universal design principles, to enable more inclusivity while enhancing the quality of the exhibition design. This new design paradigm will allow engagement with multiple modalities, encourage visitors to explore exhibits, and take advantage of new ways of imagining flexible, accessible exhibits.

Personalization can be thought of as taking UDL ideas one step further. If visitors communicate their specific needs for interacting with a museum exhibit, a digital exhibit can respond flexibly to provide an experience tuned to each visitor. Use of personalization techniques offers the exhibit designer an opportunity to create, in essence, multiple exhibits all residing within the same physical real estate.

Personalization efforts within e-learning environments have been created to help learners locate resources that are accessible to them, to turn optional access features on and off, and to automatically adjust audio or text display to settings that are best for each learner. This approach to accessibility has been standardized as Access for All (AfA), a standard from IMS Global Learning Consortium that has also been adopted by ISO and has been incorporated into metadata for Web site search engines in the Schema.org standard.
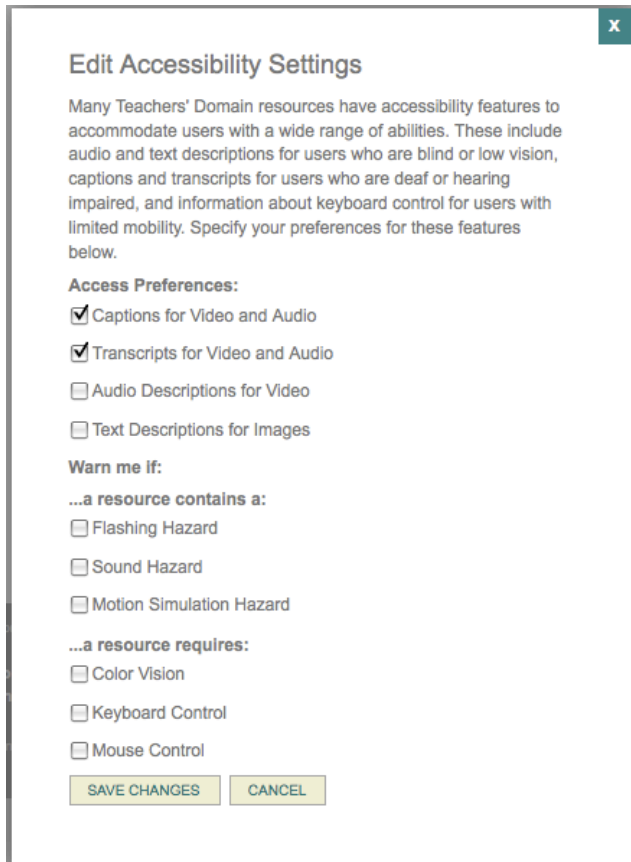
AfA "promotes an inclusive user experience by enabling the matching of the characteristics of resources to the needs and preferences of individual users" (IMS Global Learning Consortium, 2012). Access for All lays out a well defined lexicon and XML schema for describing user preferences related to interaction with digital objects, be they media, text, or user interface components. For example, an AfA implementation can store a preference for large font size when reading text. The encapsulation of user preferences allows for an extensible exhibit or kiosk design that can adapt itself to user preferences.

Many of the user preferences identified in the AfA standard represent multiple means of representation, in the UDL framework, since these are the most straightforward to identify and to adapt. However, with time and greater research, knowledge of adaptations for cognitive disabilities will expand, and more and more ways to automatically adjust interactions will be possible.

The AfA standard, while having some features relevant to physical objects, is designed for use with digital resources. Most implementations involve websites. Teachers' Domain (www.teachersdomain.org) implemented AfA in a digital library.[2] Registered users could set a series of preferences related to desired media interactions, including closed captioning, audio description, etc. Teachers' Domain allowed a registered user to set and save the following information:

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[2] Teachers' Domain is no longer available, but a video demonstrating its Access for All features is available at: http://www.youtube.com/watch?v=Bu7zrj-zYbI

Edit Accessibility Settings

Many Teachers' Domain resources have accessibility features to accommodate users with a wide range of abilities. These include audio and text descriptions for users who are blind or low vision, captions and transcripts for users who are deaf or hearing impaired, and information about keyboard control for users with limited mobility. Specify your preferences for these features below.

Access Preferences:
☑ Captions for Video and Audio
☑ Transcripts for Video and Audio
☐ Audio Descriptions for Video
☐ Text Descriptions for Images

Warn me if:
...a resource contains a:
☐ Flashing Hazard
☐ Sound Hazard
☐ Motion Simulation Hazard

...a resource requires:
☐ Color Vision
☐ Keyboard Control
☐ Mouse Control

SAVE CHANGES   CANCEL

Teachers' Domain offered several preferences for media playback for visitors with sensory disabilities, because the library contained a lot of media files. However, there were also preferences relating to hazards in content (such as flashing that could cause epileptic seizures) and warnings for resources that are color dependent or require a particular input mechanism.

Personalization can be made more convenient and pervasive by allowing people to save a set of general preferences and then apply them in many environments, including on their personal devices, at public access computers such as in libraries or on college campuses, for transactions using kiosks, and in museums. The Global Public Inclusive Infrastructure project (GPII) is creating a system that applies the capabilities of cloud-based computing to enable users to quickly adjust any user interface to meet their needs, while safeguarding privacy and security. When GPII is established, museums that offer personalization features might be a place where visitors first create their personal preferences or a place where visitors who already have preferences stored with GPII can easily apply them to the digital components of an exhibit. More information on GPII is available at http://gpii.net/.

Design Features
Personalized experiences are built with the building blocks of accessible design and multimodal features. Offering a variety of ways to learn and interact with exhibits will

make it possible to tailor each person's experience with the most useful subset of features in combination with a flexible presentation style. Here are some features that can make exhibits more accessible to a variety of visitors.

Captions

Captions are defined as synchronized text transcriptions of audio that include speaker identification, off-screen dialog indicators, and non-speech audio, and any other information conveyed solely by the audio portion of a presentation. Captions are a common feature in television programming, and the same concept can be applied to any video/audio elements. When the caption feature can be enabled or disabled by the user, it is referred to as *closed captions*. When captions are always visible, they are referred to as *open captions*. Additionally, this concept can be naturally extended to include alternate language subtitles.

An example of captioned media is available at the WGBH Media Access Group Web site: http://main.wgbh.org/wgbh/pages/mag/captioning.html

Static text is quite commonplace in exhibit design, providing primary or secondary information about specific features or even entire exhibits. Captions, however, are synchronized to some other underlying media, commonly a digital clip of video and/or audio.

The traditional method of implementing captions for video clips for public display is to create open captions, where the text is "burned in" to the picture and visible to all viewers. The advantage of this method is that it is always on and does not require any other technology over and above the video screen being used to present the clip. The disadvantage of using open captions on the video is that the rendering of the textual content cannot be personalized for display attributes like font size, color, or contrast. In addition, this technique does not allow for advanced display techniques like showing captions on a second screen or on a personal device. For museum exhibits, closed captions are encouraged since they can be adjusted in appearance for each user.

Font size/colors/contrast

Font size, colors, and contrast are text display attributes that allow underlying content to be rendered in ways that allow for easier reading.

When designing exhibits and user interfaces, separating content (the underlying textual information) from the rendering of that text (drawing words on a screen) is considered smart design. It allows for flexible rendering options.

Sometimes a static text transcription is provided for an audio/video element (or as a general annotation for an exhibit.) This is a reasonable first alternative, but it should be noted that many visitors prefer reading information to listening to it, and for those visitors, there is a wide range of comfortable text size. Additionally, some visitors require high contrast between text and background in order to read. With many font faces now available for computer interfaces, it is relatively easy to include comfortable fonts in a wide range of sizes.

Separating the text content from the exhibit component allows the text to be placed anywhere, including on a separate screen or even a handheld device that travels with the user within the exhibit. This also allows for personal accessibility preferences to be saved and acted on at multiple places in the museum, freeing the user from having to repeatedly specify the same preferences. Detaching the content from the presentation layer also offers extensibility to a wide variety of visitors, including those wishing to minimize sensory feedback.

Easy Reader Language

Offering text at multiple reading levels can enable a very wide target audience by carefully coordinating the reading level with the associated features of an exhibit. The usefulness of this technique will vary somewhat depending on the content being showcased – some complex science concepts may not be able to be effectively conveyed with less complex language.

So-called "easy-reader" captions are edited to a slower reading speed and/or easier reading level, thus providing a multi-modal enhancement designed to allow children a chance to absorb information at an appropriate level. Easy-reader captions for broadcast television were first invented at WGBH, and they were broadcast in a closed caption channel separate from the main caption stream. Providing more than one set of captions or other text allows a wider range of personalization.

Image and Video Descriptions

Originally designed for people who are blind or have low vision, video descriptions provide descriptive narration of key visual elements that are inserted within the natural pauses in dialogue (for motion video) to help low-vision viewers better understand the story. Key visual elements are those which viewers with vision loss would ordinarily miss, and include actions, costumes, gestures, facial expressions, scene changes, and onscreen text. These types of descriptions apply equally well to static objects (paintings, sculptures, maps, charts, and graphs, etc.) and to dynamic video and audio content.

Here is a link to an example of synchronized *open* video descriptions (click the play button):
http://main.wgbh.org/wgbh/pages/mag/description.html

Video descriptions were originally designed for the television environment, delivered via a separate audio service enabled in the television set. For museum environments, such a rendering technique is workable, but creates an *open-described* environment where *all* visitors hear the descriptions. A more flexible implementation might include an ancillary audio port designed for use with external headsets, or even sending audio to a separate handheld device that the visitor carries with them throughout the exhibit.

Effective Practices for Description of Science Content within Digital Talking Books is a guide to creating description for images that contain data or other important information. It offers examples of description for charts, graphs, and complex diagrams. This research-

based guide provides both general guidelines that should be followed when describing images and many examples of how the guidelines can be implemented (Gould, O'Connell, and Freed, 2008).

Audio Navigation

Audio navigation is used to allow blind and low-vision users to manipulate a device that might otherwise present a primarily visual user interface. For example, a device that uses buttons to move a cursor from field to field can be enhanced to provide feedback with audible cues that inform visitors about the current position of the cursor. A more complex example is a television set-top box that can display an electronic program guide. Audio navigation for such a device would include audible feedback for remote control commands, but also some sort of spoken feedback which voices the channels, times, program names, and other metadata. Interfaces from simple to complex can be made accessible with audio navigation. Many blind and low vision people use a software tool called a screen reader that offers audio navigation of their computer and its programs. Museums may not find it efficient to install a screen reader on every computer component in a display; instead, building in simple audio navigation supports may be more appropriate for single-purpose exhibit components. Relevant guidelines can be found in the *Developer's Guide to Creating Talking Menus for Set-top Boxes and DVDs*, which offers an introduction to audio navigation (Wlodkowski, Goldberg and Schmidt, 2003).

Audio Layering

The combination of image/video descriptions and audio navigation is called *audio layering.* This design process integrates audio feedback into an exhibit. By carefully designing audio feedback for navigation with descriptions of an exhibit's physical layout, as well as any transient or dynamic visual content (images and motion video), it becomes possible for blind and low-vision visitors to play a game, browse a data set, and engage in other exhibit experiences. This is an area of active research; more guidance may be available in the future.

Voice Control

Voice control is a feature that allows visitors to control digital interactive media using speech, and does not require holding a physical remote or learning a complex map of buttons that have visual cues and are really designed for sighted visitors. Advances in speech recognition technology now make it quite easy to convert speech into text and hence into digital commands. This is particularly true for limited lexicons (dictionaries), where speaker independence is readily achievable. Such technology lends itself particularly well to the large group of varied visitors to museums. On the other hand, if the museum space is noisy, speech recognition may be less successful.

Data Sonification and Manipulation

Like audio layering, data sonification and manipulation integrates audio feedback, image/video descriptions, and possibly voice control into an exhibit or manipulative that contains, and relies on, data sets and data analysis for understanding and participation. As described in *Effective Practices for Description of Science Content within Digital Talking Books*, communication of significant data sets or relational information relies on verbal and other auditory feedback. When visitors need to move digital objects in gaming and other

types of manipulatives, providing data sonification might involve a set of identifiable sounds that are mapped onto object states, providing a non-visual pathway for use.

Like captions, sonification can be a digital curb cut, by reinforcing visual cues and making it easier for many people to follow the flow of information. This is an area of tremendous promise for museum exhibits, which are including more and more sonification and seeing the wide-ranging benefits.

Low Clutter/Density

People with some cognitive disabilities respond well to low-clutter environments. People with these disabilities may have reduced abilities to retain information or transfer applied skills. Reducing visual or auditory clutter can be less distracting and improve the visitor's focus on an exhibit.

These goals may be hard to achieve in a busy museum setting. Providing a personalized user interface, so that the exhibit a visitor is using is greatly simplified, may provide a focus point. Museums might also offer special times of day for visitors who need a quieter experience.

Providing an optional Drill-Down mechanism can be one way to simplify a visual interface.

Optional Drill-Downs

Related to low-clutter techniques, optional drill-down features allow visitors to choose to follow connected information threads without cluttering the main display. An example might be a button that is labeled "More Information," which functions as a gateway to deeper information on a topic of interest. Typically implemented within a digital framework, optional drill-downs are a natural part of graphical user interfaces. They are also implemented in physical exhibits through the use of flip labels.

It should be noted that typical exhibit design relies on the concept of "just-enough" information. This is due to both the desire to tell a specific "story" to a specific audience, and also to the fact that physical real estate is necessarily limited in the exhibit space. Providing optional drill-downs, whether digitally or with flip labels, can alleviate some of the real estate limitations and give interested visitors a more in-depth experience. However, this depth may cause visitor fatigue as visitors spend more time at certain individual interactives, and less time in the exhibition as a whole.

Guided Tours

Subsets of exhibits clustered together to tell a complete section of the larger story can be very useful for visitors who have a low tolerance for dense material or for those with cognitive disabilities. These subsets can provide meaningful units of clarity and understanding.

By providing clearly defined maps and materials that guide visitors through an exhibit along a trajectory that has been designed specifically for such goals, museums can help visitors gain an understanding of the principles and ideas which comprise a larger exhibit.

An added benefit of such guided tours is that they can also offer plans that are useful to time-constrained groups.

The Digital Backpack

One innovative implementation of personalization for education in a museum setting is the Digital Backpack that provides support and technology to personalize learning (Basham, Meyer, and Perry, 2010). The Digital Backpack offers a targeted set of tools that enable students to creatively make use of museum resources. The tools may include a laptop and video camera or environmental sensors, and instructional support materials that help students engage in meaningful learning activities in the museum, such as making a video about what they have learned about the exhibit topic, or creating a digital poster about the museum.

Providing visitors with a personalized accessibility toolbox, like a Digital Backpack, could be another approach to improving museum access for visitors who otherwise struggle to use standard museum features.

Scaffolding for People of Different Cognitive Levels

Not really a feature so much as a design technique, scaffolding encapsulates the notions described above in Audio Layering but applies it to the cognition space. By including multiple levels of content and modes of interaction within an exhibit, a wider audience can be targeted without necessarily requiring more real estate within the museum. Each exhibit can actually become multiple exhibits. And with the use of guided tours, *sets* of interactives and manipulatives can become multiple exhibits. Even the more passive guided tour described above can be considered an example of scaffolding.

Scaffolding is a more general design approach to incorporating the entire range of accommodations to create a framework that provides support at each interactive point to promote cognitive, psychomotor, and other learning skills and knowledge.

Setting Preferences for Museums

A museum might receive hundreds or thousands of visitors in a day, and any number of them might benefit from or even require specific accommodations and features. One of the challenges, beyond designing the specific exhibit accommodations, is to create a mechanism by which visitors can use the accommodations. In the simplest case, each individual exhibit contains all of the user interface components necessary to enable all of the associated accommodations. This setup requires a visitor to enable a desired accommodation at *every* station. While workable, such an arrangement is cumbersome and repetitive.

A more elegant and friendly approach is to offer a mechanism by which a visitor might express a set of preferences that would *follow the visitor* around the exhibit so that it could be enabled whenever that visitor is engaged at a supported station.

The goal is to create an infrastructure that allows a visitor to easily enable the specific subset of accommodating features that are the most helpful. For example, a blind visitor might wish to have audio navigation and image descriptions enabled at each station that she visits. Another visitor might require closed captions at stations that incorporate motion video with audio content. Here is a possible path to creating this kind of personalization.

Collect Preference Settings

One visitor might desire all video content that has associated audio content to have closed captioning support turned on, when available. Another visitor might prefer that audio narration support is enabled for all visual content, when available. A third visitor needs larger font sizes for all textual material. And some museums offer alternative Spanish language for both audio and text. The challenge is to develop an interactive process that can glean from the visitor a concise compilation of the preferred accommodations. The example interface below was developed by the Personalization working group at the CMME Concept Development Workshop,[3] and doesn't represent a polished final interface. However, it explores the kinds of options that might be useful in a museum setting.

An interactive session might begin with a question regarding the desired language preference:
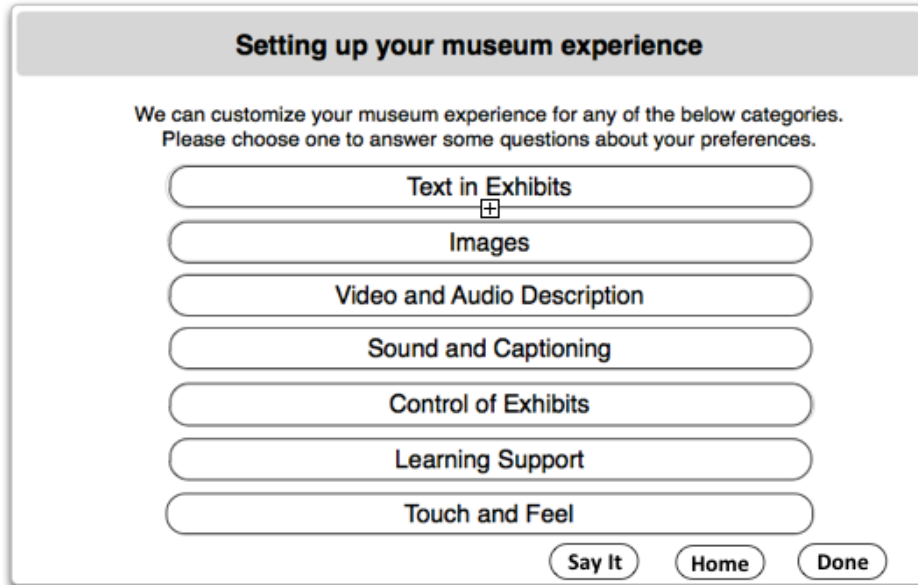
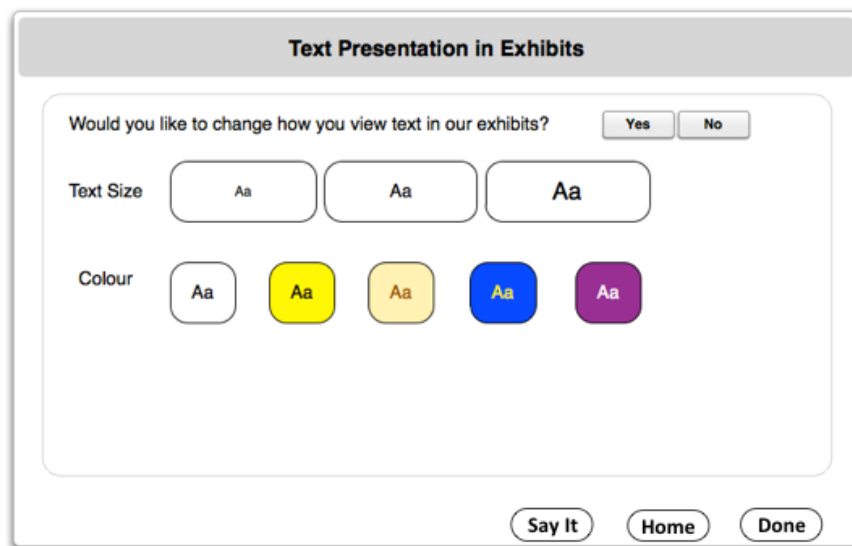

If "English" had been chosen, perhaps the following selection would prompt the visitor to explore the various types of available accommodations:

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[3] Learn more at: http://openexhibits.org/accessibility/cmme-workshop-part-2-developing-innovative-accessible-digital-interactives/7089/

Setting up your museum experience

We can customize your museum experience for any of the below categories. Please choose one to answer some questions about your preferences.

- Text in Exhibits
- Images
- Video and Audio Description
- Sound and Captioning
- Control of Exhibits
- Learning Support
- Touch and Feel

Say It   Home   Done

The offerings for "Text Presentation in Exhibits" might be:

Text Presentation in Exhibits

Would you like to change how you view text in our exhibits?   Yes   No

Text Size   Aa   Aa   Aa

Colour   Aa   Aa   Aa   Aa   Aa

Say It   Home   Done

Visitors might go through all of the possible options until each preference has been selected or declined.

The wording of the queries is important. In the section about "Text Presentation in Exhibits," the question is not "Do you have poor eyesight?" Rather, it is a query about the preferred appearance of text. Questions should be phrased in such a way as to elicit a desired presentation mechanism rather than trying to intuit a specific disability. Many visitors who have such preferences do not self-identify with a disability. This is because most of the accommodations discussed offer an advantage far beyond any single demographic. Just like curb cuts impacted many pedestrians as well as wheelchair users, a

wide range of visitors who do not consider themselves visually impaired can nonetheless benefit from larger fonts or better contrast.

Research is underway, funded by the U.S. Department of Education, on effective ways to elicit user preferences for accessibility settings such as these. The Preferences for Global Access project, a part of the Global Public Inclusive Infrastructure (GPII), aims to provide guidance for this preference collecting process. GPII will, eventually, provide the means to securely and conveniently apply preferences across environments, so that every environment, from the home computer to a smart phone, train station kiosk, or museum exhibit, can be automatically adjusted for each person.

In a museum setting, the preferences selection interface might be presented to the visitor at a number of different venues:

- public website prior to visit
- kiosk in the main welcome area
- customer service desk
- kiosks within the exhibit areas

The method chosen will depend on specific logistics and available resources, expected traffic through the preference activity, and other relevant factors for each museum. It would be useful to have a public web page available in addition to any on-site mechanism so that large groups with special needs can be accommodated more efficiently by setting preferences in advance.

Save Settings in a Portable Format
Once the full set of user preferences has been gleaned, they can be stored using a public standard for preferences or with an internal format. The information can then be transferred to a portable format that can either travel with the visitor from station to station or be associated with them uniquely but privately in some other way. Possibilities might include:

- disposable radio frequency identification (RFID) tags
- disposable barcode bracelets
- fingerprint
- location mapping using the visitor's own mobile device

An interesting new technology for location mapping is now available using special LED lighting that can sense the presence of a specific mobile device. It is accurate within 1 foot. One possible use for this would be for a visitor to step up to an exhibit and, through their own mobile device, their location would be detected and the component would adjust to their preferences.

The method selected will determine necessary downstream equipment at stations or clusters, and will in turn be governed by available resources.

The choice of data format for storing the visitor's preferences is somewhat arbitrary, and in the short term only needs to service the local implementation. There are standardized specifications, however, which have been designed for just this purpose. Specifically, the Access for All standard, from IMS Global, has been designed to support personalization for accessibility. The use of such a standard, rather than a locally developed schema, can enable portability by encouraging compatibility and interoperability. Eventually, as GPII becomes widespread, visitors might be able to use their preferences in museums as they use them in other venues.

Recover Settings and Act on them at a Station

A number of technologies might be used to retrieve the visitor's preferences as they move through the museum. How the individual exhibits or interactives read the visitor's preferences will depend on the technology selected for storing the preferences. In all cases, as the visitor uses each interactive or other exhibit, they will benefit from accommodations that are selected automatically to meet their needs seamlessly.

An Example Exhibit

Imagine that a visitor who is Deaf approaches a digital interactive exhibit, consisting of a video screen and 3 physical buttons below it. The screen contains text with a description of the activity and instructions on using the buttons to select options and perform the activity. Hidden within the station is an RFID reader, which picks up the preference settings from an RFID tag embedded in a disposable bracelet that was dispensed through a display in the entryway of the exhibition. The Personalization System decodes the preference set encoded into the RFID chip, and knows that this visitor wants closed captions and sign language when available and very large font sizes for on-screen text. The presentation engine, which is hosted in HTML5 and styled with CSS and javascript, is able to dynamically repaint the screen with large type and add a scroll bar so that the visitor can easily read the text. Furthermore, when the associated video clip plays, closed captions are automatically turned on and a small window opens with sign language interpretation so that the visitor does not require her companion to translate via sign language, which is a common occurrence for her at museums. When the RFID chip is no longer sensed, the video clip, which plays in a loop, turns its closed captions off and removes the sign language interpretation, which is fortunate because the next visitor is one who is very sensitive to visual clutter and prefers no extraneous information. By being able to adapt its playback and presentation to each visitor, the exhibit is made friendlier and more widely accessible.

In another part of the gallery, a 75-year-old grandfather and his nine-year-old grandson approach a different digital interactive exhibit, and both of these visitors are wearing the wristbands with RFID tags as described above. This exhibit is a two-person activity where visitors are asked to discuss social issues that connect to current scientific research. The grandfather sits down on one side of the exhibit and his grandson sits down on the other; each side of the exhibit has its own screen and audio output. This activity prompts each visitor to read through a series of scenarios connected to the specified social issue, and then to discuss those scenarios with his partner at different points in time. The grandfather, who wears hearing aids but does not consider himself to be someone with a

disability, has set his personalization preferences to a no-audio version—extra background noise makes it difficult for him to hear his grandson when he speaks. In contrast, his grandson has set his personalization preferences such that text on the screens will be read aloud, unless he chooses to turn the audio feature off at individual stations. He has chosen this preference because he is dyslexic and finds some of the content in the gallery difficult to read. The grandfather and grandson use this interactive together, but each has set his preferences differently.

Later, a mother with low vision and her five year-old daughter visit another digital interactive exhibit in the same gallery, and they, too, are wearing the wristbands with RFID tags. This exhibit features a series of tactile models of skulls that you can touch and feel, and also includes a computer screen and speakers as well as a push button interface. Visitors can use the push buttons to scroll through various questions that prompt them to notice and explore different features of the skulls. The mother set her personalization preferences so that the text is always enlarged and read aloud. Although she prefers to read text as opposed to learn through audio, she knows her daughter prefers to have the audio (since she has not yet learned to read). Making both output options available at all times helps the mother and daughter to interact together as they use each exhibit.

References and Other Resources

The Americans with Disabilities Act Checklist for Readily Achievable Barrier Removal
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Wlodkowski, T., Goldberg L., & Schmidt, C. (2003). *Developer's Guide to Creating Talking Menus for Set-top Boxes and DVDs*. The WGBH National Center for Accessible Media. Available at: http://ncam.wgbh.org/invent_build/analog/talkingmenus